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SEPARATE

CONTROL OF CATERPILLARS

On Commercial Cabbage
and Other Cole Crops
in the South

- Cabbage
- Broccoli
- Cauliflower
- Collards
- Kale



Farmers' Bulletin No. 2099

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UNITED STATES DEPARTMENT OF AGRICULTURE

This publication is intended for the commercial grower of cole crops in the South. For recommendations on the control of insects on these crops in the home garden, see Home and Garden Bulletin No. 44, "Cabbage Insects—How To Control Them in the Home Garden."

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Control of Caterpillars

on Commercial Cabbage and Other Cole Crops in the South

By W. J. REID, Jr., and F. P. CUTHBERT, Jr., *entomologists,*
Entomology Research Branch, Agricultural Research Service

The feeding of caterpillars on cabbage and other cole crops reduces the income of southern growers by millions of dollars each year. The losses are accounted for in part by damaged crops—lower yields and lower quality—and in part by the cost of combating these insects.

Cole crops other than cabbage that are attacked by caterpillars in the South are broccoli, cauliflower, collards, and kale. Brussels sprouts and kohlrabi are also attacked by caterpillars, but are not grown extensively in the South.

The caterpillars can be controlled by applying insecticides, but no single insecticide will control all of them. In order to select effective insecticides, you must be able to identify the caterpillars attacking your crop.

THE CATERpillARS AND HOW THEY DAMAGE PLANTS

At least 13 kinds of caterpillars damage cabbage and other cole crops in the South. They can be grouped according to their destructiveness:

1. *Those causing major damage throughout the South.*—They are the cabbage looper, the imported cabbageworm, larvae of the diamondback moth, the corn earworm, and several species of cutworms.

2. *Those causing serious damage in some parts of the South.*—They are the cabbage webworm, the cross-striped cabbageworm, and the fall armyworm.

3. *Those causing only occasional and usually minor damage in the South.*—The southern cabbage

COMMON AND SCIENTIFIC NAMES

Black cutworm.....	<i>Agrotis ypsilon</i>
Cabbage looper.....	<i>Trichoplusia ni</i>
Cabbage webworm.....	<i>Hellula rogatalis</i>
Corn earworm.....	<i>Heliothis zea</i>
Cross-striped cabbageworm.....	<i>Evergestis rimosalis</i>
Diamondback moth.....	<i>Plutella maculipennis</i>
Fall armyworm.....	<i>Laphygma frugiperda</i>
Granulate cutworm.....	<i>Feltia subterranea</i>
Gulf white cabbageworm.....	<i>Ascia monuste</i>
Imported cabbageworm.....	<i>Pieris rapae</i>
Salt-marsh caterpillar.....	<i>Estigmene acrea</i>
Southern cabbageworm.....	<i>Pieris protodice</i>
Variegated cutworm.....	<i>Peridroma margaritosa</i>



TC-3851

Figure 1.—Adult and larva of the cabbage looper.

worm, the Gulf white cabbage-worm, the salt-marsh caterpillar, and a few others are in this group.

Cabbage Looper

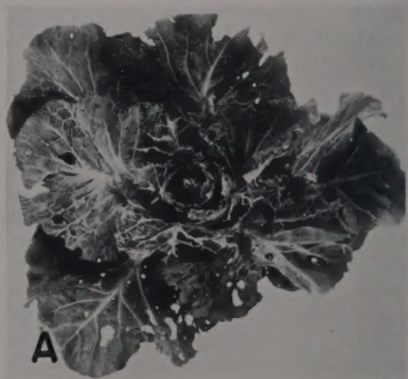
The cabbage looper usually is the most destructive of the caterpillar pests of cole crops in the South. It is the caterpillar of a medium-sized, grayish-brown moth. The moths have a silvery spot near the middle of each of the front wings that looks like a figure 8. The moths ordinarily fly near the ground and are most active at night. They have a wingspread of $1\frac{1}{4}$ to $1\frac{1}{2}$ inches.

The moths lay their greenish-white eggs singly. They lay the eggs chiefly on the lower surfaces of the outer leaves of the plants. The eggs are smaller than a pin-head, are ridged, and are almost round.

When first hatched, the caterpillars have dark heads and almost colorless bodies. They later become pale green, and have several whitish, lengthwise stripes that fade considerably as the caterpillars grow. When mature, the caterpillars are about $1\frac{1}{2}$ inches long. They crawl by doubling up, or forming a loop, then projecting the front part of the body forward.

Pupae are copper colored. They are encased in loosely woven cocoons that are attached to a leaf on the plant, a fallen leaf, or debris near the base of the plant.

Newly hatched cabbage loopers usually eat out small areas on the underside of plant leaves. As the caterpillars become larger, they move nearer to the center of the plant and eat entirely through the



TC-7009, TC-40.2B

Figure 2.—Injury caused by cabbage loopers: A, Typical injury to center part of a cabbage plant. B, Full-grown looper feeding on a leaf. Note the characteristic notches along edges of the leaf.



Figure 3.—Adult and larva of the imported cabbageworm.

TC-3851

leaves between the veins, or feed inward from the edges of the leaves. Large loopers are heavy eaters and usually cause serious damage to the marketable portion of the plants.

Imported Cabbageworm

The imported cabbageworm, sometimes called the common cabbageworm, is the caterpillar of a yellowish-white butterfly. The butterflies have several black spots on their wings, have a wingspread of about 2 inches, and are frequently seen flying in and near plantings of cole crops.

The butterflies lay eggs singly on either side of the leaves of cole crops. The eggs are yellow, oblong, bluntly pointed at the ends, deeply ridged lengthwise, and attached by one end.

The caterpillars are velvety green. They have a narrow, orange stripe down the middle of the back and a broken, yellowish stripe along each side of the body. When mature, they are about $1\frac{1}{4}$ inches long.

Pupae may be green, grayish green, or tan. They have sharp, angular projections in front and along the back, and a tough covering. They are attached by a silklike thread to a leaf of a host plant or to

some other object in or near the field.



TC-4010, TC-7051

Figure 4.—Injury caused by imported cabbageworms: A, Typical injury to center part of a cabbage plant. B, Imported cabbageworm on leaf.

Imported cabbageworms cause plant injury similar to that of cabbage loopers, but they are more likely to eat through the smaller veins of the leaves. They also feed nearer to the center of the plant, and do more damage to the edible part.

Larvae of the Diamondback Moth

Diamondback moths are about one-third inch long, have a wingspread of less than an inch, and are gray. The males have three light-yellow, diamond-shaped markings on their wings. The moths move rapidly when disturbed. They fly short distances from plant to plant during the daytime.

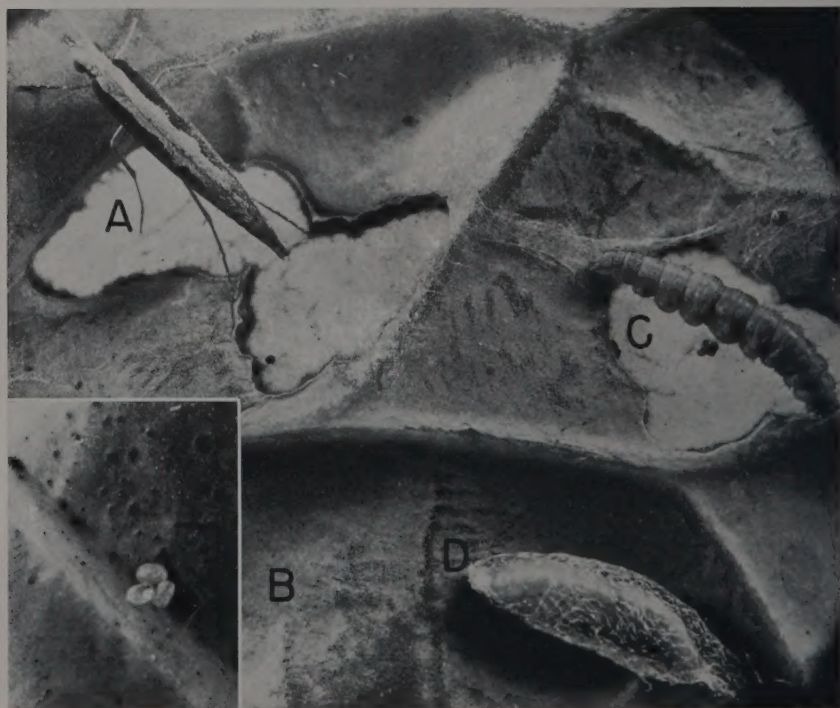
Female moths lay eggs on cole crops, singly or in groups of 2 or 3. They lay the eggs on the leaves or on the stalk near the terminal bud.

The eggs are small, almost round, and yellowish white.

The larvae are light green and slightly pointed at each end. Their bodies are covered with tiny, erect, black hairs. When mature, they are about one-third inch long. They wriggle rapidly when disturbed, often dropping from the plant and hanging by silklike threads.

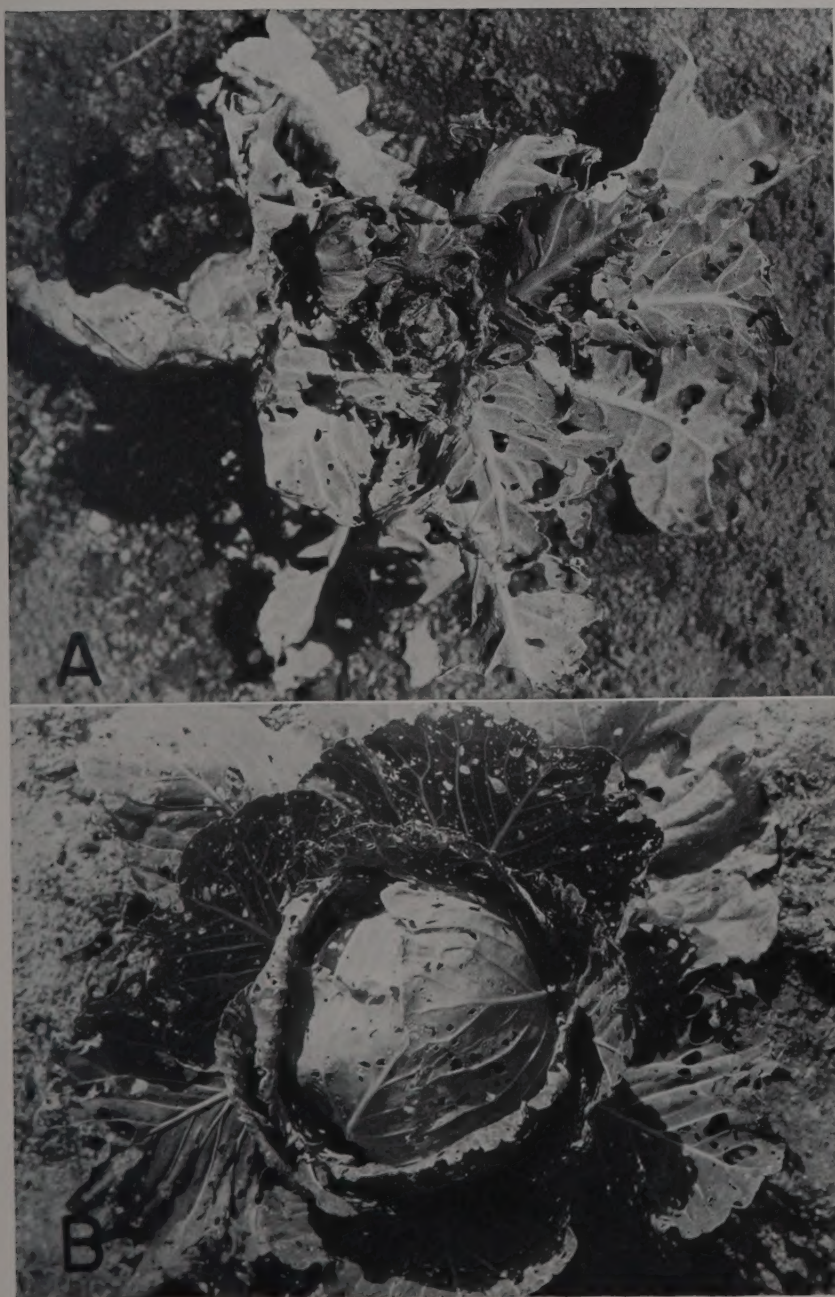
The larvae of the diamondback moth feed on all parts of the plant, but they prefer places around the bud of a young plant, crevices between loose leaves of a firm head, and the underside of lower leaves. Their feeding may disfigure the bud of a young plant so that the head or other marketable portion will not develop properly.

The pupae are encased in loosely woven, gauzelike cocoons that are



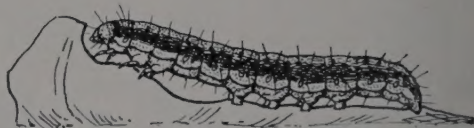
TC-7013, TC-7014

Figure 5.—The diamondback moth: A, Female moth with wings folded. B, Eggs. C, Larva. D, Pupa.



TC-7253, TC-7254

Figure 6.—Injury caused by larvae of the diamondback moth: *A*, Young cabbage plant with badly injured bud. *B*, Typical injury to an older plant.



TC-3851

Figure 7.—Adult and larva of the corn earworm.

fastened to the leaves of the host plant or in crevices near the plant bud.

Corn Earworm

The corn earworm is also known as the tomato fruitworm or the cotton bollworm. It is the caterpillar of a night-flying moth that has a wingspread of about $1\frac{1}{2}$ inches. The moths vary in color from light olive green to grayish brown or yellowish brown.

Female moths lay their eggs on the leaves of cole crops or on grasses nearby. The eggs are ribbed, shaped like a flattened ball, and light yellow to dusky brown.

Newly hatched corn earworms are whitish and have black heads. The older ones are green, greenish brown, or greenish black; they are usually marked with stripes of yellow, brown, green, and black; they

have yellow heads. Full-grown earworms are about $1\frac{1}{2}$ inches long.

Mature caterpillars burrow 2 to 6 inches into the soil and transform into shiny, light-brown pupae about three-fourths inch long.

A single corn earworm may seriously damage or destroy the bud of a cole crop plant, causing the plant to be disfigured or to produce several secondary buds. Earworms may disfigure the heads of cabbage plants by their feeding and tunneling.

Cutworms

Several species of cutworms, including the black cutworm, the variegated cutworm, and the granulate cutworm, attack cabbage and related crops in the South.

Cutworms are the caterpillars of night-flying moths. The moths range in color from gray to brown and have varied designs of stripes and spots. They have a wingspread of about $1\frac{1}{2}$ inches.

The moths lay their eggs on the leaves of grasses, weeds, and other host plants, and sometimes on bare ground.

The cutworms are smooth skinned and somewhat shiny. They range in color from gray to brown and almost black. Some of them have distinctive markings of stripes and spots.

The shiny, brown pupae are about three-fourths inch long and are found underground.



TC-7036

Figure 8.—Cabbage head damaged by the corn earworm.



TC-2935

Figure 9.—Young cabbage plant whose stalk and leaves were cut off by a cutworm.

Cutworms feed mostly at night and hide during the daytime on or just below the soil surface. They cut off the stalks of young plants; they also feed on the leaves, buds, and heads.

Cabbage Webworm

The cabbage webworm is the caterpillar of a moth that has front wings of brownish yellow mottled with darker brown, and hind wings of pale gray. The moths have a wingspread of a little more than one-half inch. When disturbed in the field, the moths make short, uneven flights, and come to rest quickly among the leaves of a plant or on the ground, where their color blends with that of the soil.

Female moths lay grayish-white eggs near the buds of young host plants. As the plants approach maturity, the moths prefer to lay their eggs on the underside of a leaf in the angle along the leaf stems.

The webworms are about one-half inch long when mature. They are dull grayish yellow, and marked with five conspicuous brownish-purple lengthwise stripes. Their heads are black and bear a V-shaped mark.

When first hatched, the caterpillars feed on either side of the partly folded leaves of the plant bud. After a few days, the caterpillars begin to feed beneath a protecting web made from silklike threads that they secrete. Sometimes the caterpillars are found on the outer leaves or along the main ribs of leaves and along the main plant stalk in a leaf axil. They can be



TC-7016

Figure 10.—Cabbage webworms, approximately full grown.



TC-7017

Figure 11.—Cabbage webworm feeding on the bud of a young cabbage plant. To show it, the web was removed and the leaves were partly infolded.

detected by the debris and the webs at the point of feeding.

The shiny, light-brown pupae are about one-fourth inch long. They are formed in a web that is attached to fallen leaves and other debris on the soil surface.

Cabbage webworms tunnel into and kill the buds of young plants of cabbage and related crops. One webworm can ruin a young plant. Destruction of the original bud causes the production of secondary

ones that rarely develop into firm heads by harvesttime. Less severe injury may disfigure the head produced from the original bud. Feeding of this insect on the outer leaves of older plants usually does little harm.

Cross-Striped Cabbageworm

The adult of the cross-striped cabbageworm is a moth that has a wingspread of about 1 inch. The front wings are mottled yellowish



TC-7018, TC-7020, TC-7019

Figure 12.—Cabbage webworm injury to cabbage plants: *A*, Multibudded plant resulting from earlier destruction of the terminal bud. *B* and *C*, Plants with disfigured buds caused by earlier feeding by webworms.



TC-7029, TC-7070

Figure 13.—Adult and larvae of the cross-striped cabbageworm.

brown to brown, and are marked with zigzag lines of dark brown. The hind wings are lighter in color than the front wings. They are almost transparent at the base, darker at the front, and marked across the free end with a row of 5 or 6 small, indistinct dusky spots.

The female moths lay eggs on the underside of the leaves of cole crops in masses of 20 to 30. The eggs overlap one another like shingles on a roof. The eggs are light yellow and semitransparent.

When first hatched, the cabbageworms, or caterpillars, are gray. They are about three-fifths inch long when full grown and have numerous tiny black stripes across bluish gray backs. Along each side of the back is a black stripe; below the black stripe on each side of the body is a bright yellow stripe. The underside of the body is light green, mottled with yellow.

The caterpillars enter the soil and pupate just below the soil surface in a tight cocoon. The pupae are



TC-7031

Figure 14.—Cabbage plant injured by the cross-striped cabbageworm. Note that the ends of the leaves are not eaten off as in figures 2, A and 4, A and that the holes are smaller.

about one-half inch long and light yellowish brown to dark brown.

Cross-striped cabbageworms prefer the tender terminal buds and the heads of cole-crop plants; they riddle them with holes. Because the eggs are laid in clusters, large numbers of the caterpillars hatch on individual plants scattered over a field.

Fall Armyworm

The fall armyworm is the caterpillar of a night-flying moth that has a wingspread of about 1½ inches. The body of the moth is ash gray. Forewings of the male are dark-gray ground color and have a mottled appearance; they usually have an irregular white or light-gray spot near the tip. Forewings of the female usually are darker than those of the male. Hind wings of both sexes are white; they have a pearly or pinkish luster, and are edged with a smoky-brown line.

The eggs are light gray, are covered with a grayish down that comes from the body of the moth, and are laid in clusters of 50 or more, usually on blades of grass.

When first hatched, the caterpillars are grayish white and have jet-black heads. Full-grown fall armyworms are about 1½ inches long. They have lighter colored heads than when newly hatched. They have few hairs on their bodies, which are striped and light green

to almost black. They have a black band on each side of the body and usually have a whitish inverted Y marking on the front of the head.

The pupae are shiny, reddish to almost black, and about three-fourths inch long. They are formed 1 or 2 inches underground.

Fall armyworm damage to cabbage and related crops occurs chiefly when the plants are small. The injury is similar to that caused by the cabbage looper.

Southern Cabbageworm

The southern cabbageworm is the caterpillar of a white butterfly that looks like the adult of the imported cabbageworm, except that it has more checkered black spots.

The caterpillars are about 1 inch long. Their color ranges from bluish to purplish to green. They are marked with four yellow stripes lengthwise on the body, and with small black dots.

The pupae are bluish green and spotted. In shape, size, and location they are similar to pupae of the imported cabbageworm.

The injury to cabbage is similar to that caused by the imported cabbageworm.

Gulf White Cabbageworm

The Gulf white cabbageworm is the caterpillar of a white butterfly that looks like the adult of the imported cabbageworm.

The caterpillars are 1½ inches long when mature. They are yellow and have four purplish stripes.

Gulf white cabbageworm injury to cabbage and related crops is similar to that caused by the imported cabbageworm.

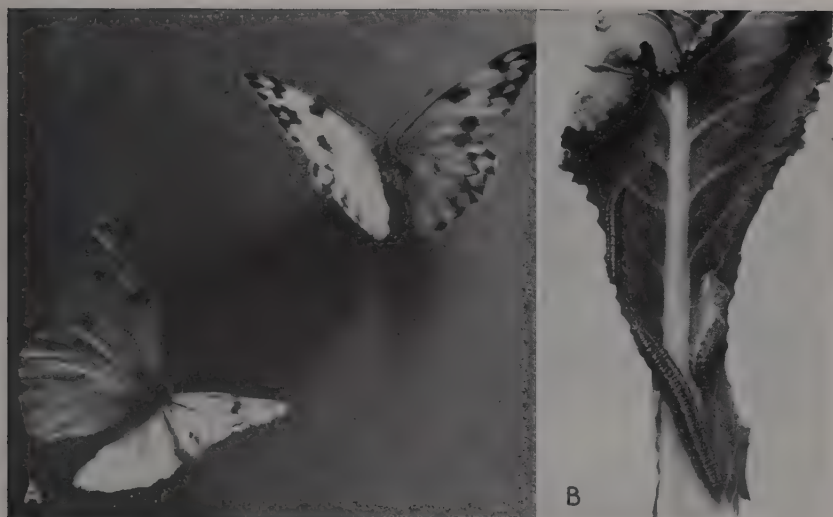
Salt-Marsh Caterpillar

Salt-marsh caterpillars are the larvae of a white moth that has yellow and black markings on the abdomen and black dots on the wings.



C & F-489

Figure 15.—Adult and larva of the fall armyworm.



TC-7272, TC-7273

Figure 16.—The southern cabbageworm: A, Adults—male (left) and female. B, Larvae and pupa on cabbage leaf.

The larvae belong to a group of insects known as woolly-bear caterpillars. They are $1\frac{1}{2}$ to 2 inches long when full grown. The bodies of salt-marsh caterpillars are partly covered by long reddish-brown to black hairs that give them a woolly appearance.

The pupae are found under trash, dead leaves, and other shelter on top of the soil. They are in thin silken cocoons covered with interwoven hairs from the body of the caterpillar.

Salt-marsh caterpillars feed on the outer leaves of cole crops, especially on plants near outer margins of the field. The injury is similar to that caused by the cabbage looper.

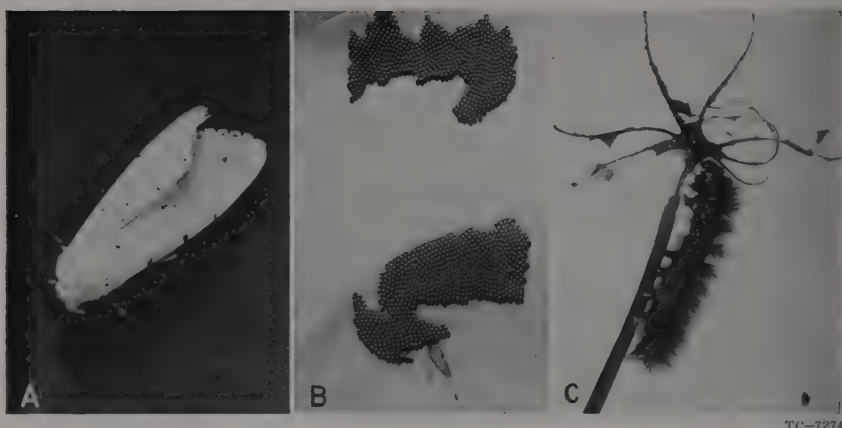
WHEN AND WHERE THEY OCCUR

Caterpillars may injure winter plantings of cole crops in Florida and southern Texas at any time during an average winter. They attack summer plantings in mountainous sections during the summer and early fall. They are usually most

destructive during the spring and fall in other sections of the South.

Winter crops in Florida and southern Texas are injured by imported cabbageworms, cabbage loopers, cabbage webworms, corn earworms, cutworms, and larvae of the diamondback moth. Diamondback moth caterpillars develop at lower temperatures than most other cabbage caterpillars and are favored by mild, dry winter and spring seasons. The Gulf white cabbageworm appears to be a serious pest in the South only in southern Florida, where it is the most common caterpillar on cabbage and collards in late spring and early summer.

Winter-spring plantings of cole crops in such areas of the South as coastal South Carolina and Baton Rouge, La., usually are not seriously injured by caterpillars during midwinter and early spring. A few cabbage loopers, cutworms, and larvae of the diamondback moth often are present, however, and sometimes cause considerable damage when the weather is unusually mild.



TC-7274

Figure 17.—The salt-marsh caterpillar: A, Adult female moth. B, Egg masses. C, Caterpillar.

Later plantings—those harvested in April and May—usually are seriously injured in these areas by the cabbage looper, the imported cabbageworm, and larvae of the diamondback moth. Populations of these caterpillars ordinarily increase rapidly, and control measures usually are needed on spring plantings in these areas when weekly mean temperatures reach 60° F. for 3 consecutive weeks.

Summer-grown crops in the mid-South, especially those grown in the mountains of western North Carolina, northern Georgia, and southwestern Virginia, may be injured by cabbage loopers, imported cabbageworms, cross-striped cabbageworms, and cutworms. Larvae of the diamondback moth sometimes injure these plantings, and cabbage webworms may appear in late summer and fall.

Fall plantings seeded directly in the field in the mid-South may be injured by caterpillars from the time they come up until temperatures are consistently below 50° F. Such temperatures usually occur after mid-November around Baton Rouge, La., and Charleston, S. C. Short cold periods, even though frosts and freezing temperatures may occur, only cause the caterpillars

to seek protected places in the plants. Fall plantings are usually subject to severe injury by cabbage webworms, cutworms, fall armyworms, cabbage loopers, corn earworms, and imported cabbageworms. Cutworms and fall armyworms are especially abundant when grass is grown in a field before cabbage is planted or is allowed to grow with cabbage or other cole crops. Corn earworms often feed on fall cabbage when corn is no longer available. Larvae of the diamondback moth often appear on fall crops while they are being harvested.

In general, weather conditions favorable to the growth of cole crops also favor the development of caterpillars.

Caterpillars do not thrive when temperatures are extremely high or low, or when there is severe drought or heavy rainfall. Excessive rainfall is particularly unfavorable to the larvae of the diamondback moth. Caterpillars usually are inactive when the temperature is well below 50° F.

Frequent summer and fall rains cause rapid growth of grasses in cabbage fields; this increases the number of fall armyworms and cutworms.

USING INSECTICIDES

Insecticide applications are usually necessary to control caterpillars on cabbage and other cole crops. Not all kinds of caterpillars can be killed with a single insecticide, and several kinds of caterpillars may appear at the same time.

Crops grown late in the spring, during the summer, and in the fall usually require the greatest number of applications and the highest dosages of insecticides. Plantings grown in southern Florida and Texas during the winter also require insecticide control measures.

The kind of insecticide to use depends on the kinds of caterpillars present, and on whether the plants have begun to form the parts that are to be eaten or marketed.

Unfortunately, the insecticides that are most effective against cabbage caterpillars leave poisonous residues that persist for a long time on the parts of the plant on which

they are applied. Toxaphene and DDT should not be applied after parts that are to be eaten or marketed appear. Parathion evaporates slowly but should not be applied within 21 days of harvest. Useful insecticides that can be applied to parts of the plant that are to be marketed include malathion, rotenone, and pyrethrum.

The marketed portions of cabbage and broccoli usually appear at the time the heads or flower buds begin to form, or 30 to 40 days before harvest of early-maturing varieties normally begins. The marketed portion of cauliflower appears when the curds are about one-half inch in diameter. This size ordinarily is reached 30 to 40 days before harvest begins. The edible portions of collards and kale, of cabbage to be marketed with more than 4 loose outer or "wrapper" leaves, or of cabbage to be cut before the head becomes hard, may appear 60 days before harvest.



TC-7285, TC-7257

Figure 18.—Effect of a 10-percent toxaphene dust in the control of the cabbage looper, the imported cabbageworm, and larvae of the diamondback moth on cabbage: A, Plants treated with 10-percent toxaphene dust before the heads began to form. B, Untreated plants in the same field.



TC-2453, TC-2175

Figure 19.—The use of DDT and toxaphene on cabbage that is to be marketed with four wrapper leaves should be discontinued when the heads begin to form. Plants in this stage of development are shown above: *A*, Plant of the pointed-head type (Charleston Wakefield variety). *B*, Plant of the roundhead type. (Copenhagen Market variety).

To obtain best results in controlling caterpillars with insecticides you should: (1) Watch the crops closely to find out when caterpillars appear and what kinds are present; (2) begin applying the right insecticide at once; (3) try to have the plants free of caterpillars, especially cabbage webworms, when thinned or transplanted, and try to have them free of cabbage loopers and corn earworms when the marketable parts of the plants become exposed; and (4) apply toxaphene or DDT just before the marketable portions of the plants appear (see fig. 19) even though few caterpillars are present. Preventive applications should be made at this time because the insecticides that can safely be applied later will not control the corn earworm, cutworms, the salt-marsh caterpillar, or the fall armyworm, and are only partially effective against other kinds of caterpillars.

For a number of years DDT gave excellent protection against the cabbage looper, but it can no longer be depended on to control this insect. Parathion, toxaphene, malathion, and rotenone usually give only partial control, but they are the most satisfactory insecticides that can be recommended at this time. Consult your State agricultural experiment station or county agent for the latest developments on the control of this insect.

The imported cabbageworm also has become difficult to control with DDT, but can be satisfactorily controlled with parathion or toxaphene.

DDT will control the corn earworm and certain other kinds of caterpillars, but usually will not provide adequate protection when used alone. When toxaphene is being used and the corn earworm becomes a problem, as it may during the fall, DDT can be used in combination with the toxaphene or can be applied separately.

Use table 1 on page 18 as a guide for the selection and use of insecticides in the control of the more destructive caterpillar pests of cabbage and related crops. Table 2 on page 19 gives effective formulations and dosages of the insecticides. Dusts, wettable powders, or emulsifiable concentrates of different strengths than those in table 2 may be used if they are applied at a rate that will provide the recommended dosage of the active ingredient.

The amounts of active ingredient per acre in table 2 may be increased or decreased by not more than about 25 percent to compensate for variations in the size of plants and the nature or degree of caterpillar infestation. Dosages of insecticides applied to plant beds should be about 50 percent higher than those in table 2. Impregnated pyrethrum dusts usually are more effective than those of the same pyrethrins strength prepared directly from pyrethrum powder. The pyrethrins content of the rotenone-pyrethrum dust and the amount of pyrethrins applied per acre should be 50 percent higher (0.15 percent and 0.0375 pound, respectively) than the figures given in table 2 if the dust is prepared from a pyrethrum powder. Dusts prepared directly from a rotenone-containing powder usually are as effective as those made from a rotenone-impregnated dust base.

The effectiveness of a rotenone dust, and of a rotenone-pyrethrum dust prepared from the powder, can be increased by adding 2 percent of a mineral oil, 0.5 to 1 percent of piperonyl cyclonene, or 10 percent of sulfur. Use a light grade of paraffin-base refined mineral oil having a viscosity of approximately 75 seconds Saybolt (100° F.) and an unsulfonated residue of approximately 90 percent. Additives usually are of most value in the control of the cabbage looper. The strengths and dosages of rotenone

TABLE 1.—*Guide for Selection and Use of Insecticides for Caterpillar Control on Cole Crops*

Insect	Insecticide		Timing of application
	Before portion to be marketed appears	After portion to be marketed appears	
Cabbage looper ¹ Imported cabbageworm	Parathion or toxaphene	Malathion (until 7 days before harvest), rotenone, or combination of rotenone and pyrethrum.	Begin as soon as there is an average of about 1 caterpillar per plant or there are signs of recent feeding on about $\frac{1}{4}$ of the plants; repeat every 7 days.
Diamondback moth larvae	Toxaphene, DDT, or parathion.		
Cross-striped cabbageworm Gulf white cabbageworm Southern cabbageworm	DDT or parathion		
Cabbage webworm	Toxaphene or DDT	Rotenone or combination of rotenone and pyrethrum.	
Corn earworm	DDT	No safe, effective material known	Begin when caterpillars first appear; repeat every 7 to 10 days.
Salt-marsh caterpillar Climbing cutworms	Toxaphene		Apply as needed. Do not apply baits on edible portion of plants.
Fall armyworm	Toxaphene or DDT	Toxaphene bait	
Soil-inhabiting cutworms	Toxaphene		

¹ Cabbage looper populations have become quite resistant to DDT throughout the South and at least moderately so to toxaphene in some areas. Parathion, malathion, rotenone, and pyrethrum often give only partial control of high populations of this insect.

TABLE 2. Formulations and Dosages of Insecticides to Use for Caterpillar Control on Cole Crops

Insecticide	Active ingredient per acre in dusts and sprays	Dusts		Sprays ¹		Baits	
		Strength at 25 pounds per acre	Percent 10 to 15	Formulation examples ²	Quantity per acre in 20 to 100 gallons of water	Formulation ²	Quantity per acre in 25 pounds of wheat bran
Toxaphene	Pounds 2.5 to 3.75			40% WP <i>or</i> 63% EC	6 to 9 pounds	40% WP plus light mineral oil. <i>or</i> 63% EC plus light mineral oil.	2.5 pounds plus 1 to 2 quarts. 1.25 pints plus 1 to 2 quarts.
DDT	2.0 to 3.0 1.25	5		50% WP <i>or</i> 25% EC 5% powder ³ <i>or</i> 5% EC	2 3/4 to 4 pints 2.5 pounds 2.5 quarts 5 pounds 2 quarts		
Rotenone	0.25	1		EC containing not less than 2% of rotenone and 0.4% of pyrethrins.	2 quarts— <i>or</i> use as directed by manufacturer.		
Rotenone plus pyrethrins.	0.125 plus 0.025.	0.5 plus 0.1					
Parathion	0.5	2		15% WP <i>or</i> 25% EC 25% WP <i>or</i> 57% EC	3 1/2 pounds 1 quart 5 pounds 1 quart		
Malathion	1.25	5					

¹ To obtain adequate coverage, you may need to add a wetting or sticking agent to some sprays, especially high-gallonage, wettable-powder sprays. In using such additives, follow recommendations of the manufacturer. Use 50 to 100 gallons of water per acre when applying a rotenone or rotenone-pyrethrum spray.

² Wettable powder is designated as WP and emulsifiable concentrate as EC.

³ If you use a rotenone powder that is not wettable, mix some of it with water to form a paste, and then add remainder of water.



Figure 20.—Value of a rotenone-containing dust in the control of the cabbage looper, the imported cabbageworm, and larvae of the diamondback moth on cabbage: The heads on the left were dusted; those on the right were not.

and rotenone-pyrethrum dusts should not be lower than those given in table 2 even though the additives are used.

Pyrophyllite, flaky talcs, and sulfur are more satisfactory carriers, or diluents, in rotenone and pyrethrum dusts than kaolin clays.

Application

Sprays or dusts do not adhere well to plants that are dripping wet with rain or dew. Do not dust or spray just before a rain is expected. Dust or spray again if one-half inch or more of rain falls within 24 hours after an application.

Adjust the nozzles of dusting or spraying equipment so as to direct the insecticide into all parts of the plant and onto both the upper and lower sides of the leaves. Be sure to get good coverage of the growing buds and the marketable portions of the plants.

DUSTING.—The best time for applying most dusts is when the plants are moist but not wet, there is little or no wind, and humidity is high. The desired conditions exist most often after sunset and early in the morning. Night dusting operations, with hand-held lights or lights mounted on the equipment, are usually effective. Early-morning dusting is satisfactory unless the plants are so heavy with dew that the dust runs off when applied to leaves. Morning dusting should be discontinued if the wind rises or the plants become dry.

A wind velocity of 3 miles per hour or more will cause plants to become too dry to hold the dust, and much of the dust will be blown from the field. A cloth, attached so as to cover the nozzles and trail 15 to 25 feet behind the dusting equipment, is useful on windy days. Unless trailers or hoods are used, do not dust when the wind velocity

exceeds 3 miles per hour. You can feel such a wind velocity on the face; it causes leaves to rustle, and will move an ordinary wind vane.

When cabbage plants are large, especially after the heads begin to form, direct 2 dust nozzles into the sides of each row at an angle of 45 degrees to the soil level. If the duster has only 1 nozzle, make 2 trips per row when dusting large or heading plants.

SPRAYING.—Spraying can be done during a greater part of the day and under more adverse weather conditions than dusting. Sprays for caterpillar control on cabbage may be applied at rates of 20 to 100 gallons per acre, except that a minimum of about 50 gallons is required to prevent nozzle clogging when a rotenone powder is applied in a spray. Emulsifiable concentrates are better to use in low-gallonage sprayers than wettable powders, but are more likely to injure the plants. The wettable powder or emulsifiable concentrate should be thoroughly mixed with the water in the spray tank before spraying begins. It should be kept mixed during the spraying operation.

Wind has more adverse effect on low-gallonage than on high-gallonage sprays.

When spraying large or heading plants, make 3 trips per row with a single-nozzle sprayer, or use 3 nozzles per row with larger sprayers. Direct one of the nozzles downward into the plants and the others into

the sides of the row at an angle of 45 degrees to the soil level.

Equipment

Rotary hand dusters, knapsack bellows-type dusters, or knapsack sprayers of the type that has an agitator and pump operated with a hand lever are suitable for use in small market gardens.

Power dusters operated by a gasoline engine or by power takeoff from a tractor, and high-gallonage or low-gallonage power takeoff sprayers, are suitable for large commercial plantings.

Low-pressure power sprayers maintain a pressure of 30 to 100 pounds per square inch and deliver 5 to 50 gallons of spray per acre. High-pressure sprayers maintain a pressure of 200 to 400 pounds per square inch and deliver 75 to 150 gallons or more of spray per acre.

Use of aircraft for applying insecticides is on the increase. Many commercial companies specialize in aerial application. Application from the air is particularly advantageous when the soil is too wet to use ground equipment, when the plants are large and cover the soil surface, or when a large acreage must be treated quickly.

Use equipment that will get insecticide to all parts of the plants. Keep the equipment clean.

PRECAUTIONS

Most insecticides are poisonous. Handle insecticides with care. Store them in closed containers where they cannot be mistaken for food or medicine, and where children, pets, or farm animals cannot reach them. See that the containers are properly labeled. Follow all directions and heed all precautions on the labels.

PROTECTION WHEN HANDLING

Wash the hands and face thoroughly with soap and water after handling insecticides, especially before eating or



TC-7058

Figure 21.—Cabbage plants just beyond the stage of growth at which cabbage webworm control measures should begin.



TC-7043

Figure 22.—Effective dusting of cabbage. The application was made on a still afternoon, just before sunset. The plants were damp enough to hold the dust, and the moist air held the dust cloud near the ground.



TC-7042

Figure 23.—Ineffective dusting of cabbage. The application was made on a clear day when the air was moving enough to dry the plants and to blow the dust out of the field. This is the same field that is shown in figure 22, and the dust was applied by the same machine (hidden by the dust cloud).

smoking. Bathe after each day's work and put on clean clothing each day.

Parathion malathion, and toxaphene are absorbed through the skin. Anyone handling or applying one of these materials should wear protective clothing. Do not let the insecticide remain on the skin.

Parathion is extremely poisonous. It may cause death if swallowed, inhaled, or absorbed through the skin. Parathion should be applied only by a person who is thoroughly familiar with its hazards and who will assume full responsibility for safe use and comply with all the precautions on the label. Do not attempt to prepare parathion dusts, but use them ready mixed.

INSECTICIDE RESIDUES

Rotenone and pyrethrum dusts or sprays do not leave harmful residues when applied to foliage. They may be applied to plants at any time prior to harvest.

Do not apply DDT or toxaphene

dusts or sprays to any part of a plant that is to be marketed or used as food.

Cabbage intended for marketing as U. S. Grade No. 1, with not more than four wrapper leaves at least two-thirds loose from the base to the tip of the head, should not be dusted or sprayed with DDT or toxaphene after the heads begin to form (see fig. 19).

Discontinue applying DDT and toxaphene to cauliflower when the curds are about one-half inch in diameter.

Do not apply DDT or toxaphene to green sprouting broccoli after the flower buds begin to form.

Do not apply DDT or toxaphene to leaves of collards or kale that are to be eaten or marketed. This often will limit the use of DDT or toxaphene to the period prior to the normal time of thinning or transplanting.

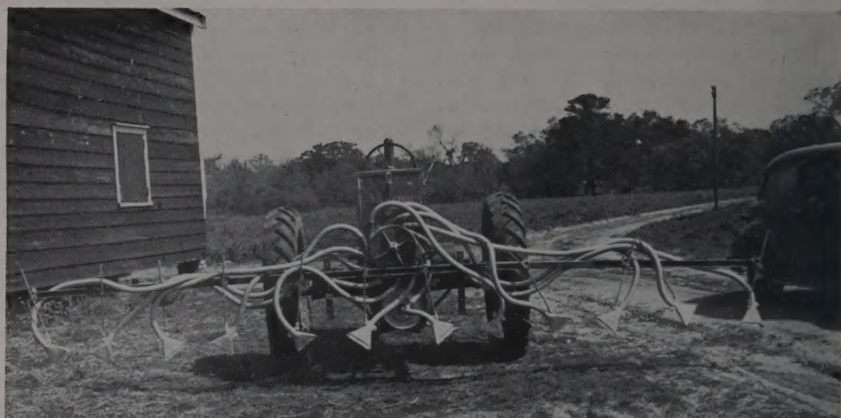
Do not apply parathion within 21 days or malathion within 7 days of harvest of any cole crop.

Plants contaminated with parathion, toxaphene, or DDT should not be fed to livestock.



TC-7087, TC-7089

Figure 24.—Equipment suitable for use in small market gardens: A, Rotary hand duster. B, Knapsack compressed-air sprayer.



TC-7044

Figure 25.—A duster of the tractor-powered type, suitable for large commercial plantings.

CULTURAL PRACTICES

The following practices help prevent caterpillar injury to cabbage plants and other cole crops:

1. Transplant spring crops as early as market and weather conditions permit.

2. Locate plantings as far as possible from older plantings that are infested with caterpillars, especially those infested with larvae of the diamondback moth.

3. Harvest cabbage as soon as it is ready for market. As soon as possible after harvest, dispose of the unmarketable plants by plowing them under or by feeding them to livestock. See precaution on page 23.

4. Seed or transplant in rows of uniform width to permit effective use of spraying or dusting equipment. Space the plants uniformly along the row and far enough apart to prevent crowding. This makes it easier to apply an insecticide to all parts of the plant. Use enough seed to insure an adequate stand, yet not so much that the young plants

will be crowded before they are thinned or transplanted.

5. Thin or transplant to a nearly perfect stand of plants with sound terminal buds. Moderate insect injury to the terminal bud often disfigures the plant; severe injury may stop growth of the terminal bud.

6. Do not transplant or thin caterpillar-infested plants before using an insecticide.

7. Provide enough fertilizers, especially the nitrogenous ones, to keep the plants growing vigorously. This will offset to some extent the effects of caterpillar feeding.

NATURAL CONTROLS

The number of caterpillars that attack cabbage and other cole crops may be appreciably reduced at times by other insects and by diseases, birds, and spiders. Natural controls, however, will not provide sufficient protection and little reliance should be placed on them in carrying on caterpillar-control programs.